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COMPARISON OF SILVICULTURAL METHODS AT COYOTE CREEK WATERSHEDS IN SOUTHWESTERN OREGON--A CASE HISTORY

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ABSTRACT

Three similar southwestern Oregon watersheds, all having cool and moist climates, were logged by different methods in 1971. Five years after logging, regeneration was adequate on all three watersheds, but most abundant under a partially cut overstory. Tractor yarding compacted the subsoil, but seedling heights were similar on tractor and high-lead areas in 1976. Scarified, tractor-yarded areas regenerated most promptly.

KEYWORDS: Cutting systems (silvicultural), regeneration (natural), logging (-regeneration, watershed management, Oregon (Umpqua National Forest), Oregon (southwestern).

INTRODUCTION

Mixed conifer forests in southwestern Oregon contained approximately 10 percent of the Nation's softwood sawtimber in 1959 (Hayes 1959). Much of this timber has been cut since then, but the remaining old-growth forests constitute an extremely valuable resource. This uncut reservoir of old-growth timber will become progressively less important as logging operations continue, and southwestern Oregon's forest product industry will become increasingly dependent on the young forests that replace harvested old-growth stands. Unfortunately, prompt replacement of old-growth stands by vigorous young forests does not always occur. Hundreds of thousands of acres in southwestern Oregon do not support conifer stocking (MacLean 1976). Directly or indirectly, most of these unstocked acres are the result of logging operations.

Depending on the environment in which it is applied, a given timber harvesting technique may or may not create forest regeneration problems. Clearcutting is followed by abundant regeneration in some forest environments. In others, it creates conditions that make successful regeneration difficult. Similarly, removal of the old-growth overstory in several stages through partial cutting may be necessary in some environments but may complicate logging and hinder seedling growth in others.

Just as regeneration success varies with a given harvesting technique in different environments, so does it vary with different techniques in the same environment. It may not always be possible to identify optimal harvesting techniques in advance, but there are such techniques for every environmental situation. Yarding methods, size of cutting unit, and the amount of soil scarification and compaction are some of the variables that influence the establishment and growth of new stands in all environments. As part of a continuing effort to relate forest environments to harvesting techniques and subsequent forest regeneration in southwestern Oregon, the U.S. Forest Service is monitoring and comparing these variables on three adjacent experimental watersheds in the Umpqua National Forest.

STUDY AREA ENVIRONMENT

The three study watersheds are located in the South Umpqua River basin (T. 29 S, R. 1 E). They originally supported a mixed conifer forest containing approximately 50,000 board feet per acre (440 m^3/ha). Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), grand fir (*Abies grandis* (Dougl.) Lindl.), incense-cedar (*Libocedrus decurrens* Torr.), and sugar pine (*Pinus lambertiana* Dougl.) predominated in the old growth. Occasional ponderosa pines (*Pinus ponderosa* Laws.) and western hemlocks (*Tsuga heterophylla* (Raf.) Sarg.) were also present. Occupying adjacent drainages (fig. 1), the three watersheds comprise 171, 169, and 123 acres (69.2, 68.2, and 49.8 ha). These Coyote Creek watersheds are referred to as CC-1, CC-2, and CC-3.

Elevations range from 2,300 to 3,500 feet (700 to 1 066 m) within the three watersheds. Slopes are gentle to moderate for the most part, with occasional steep pitches exceeding 50 percent. Soils are loams, silt loams, and silty clay loams, developed from

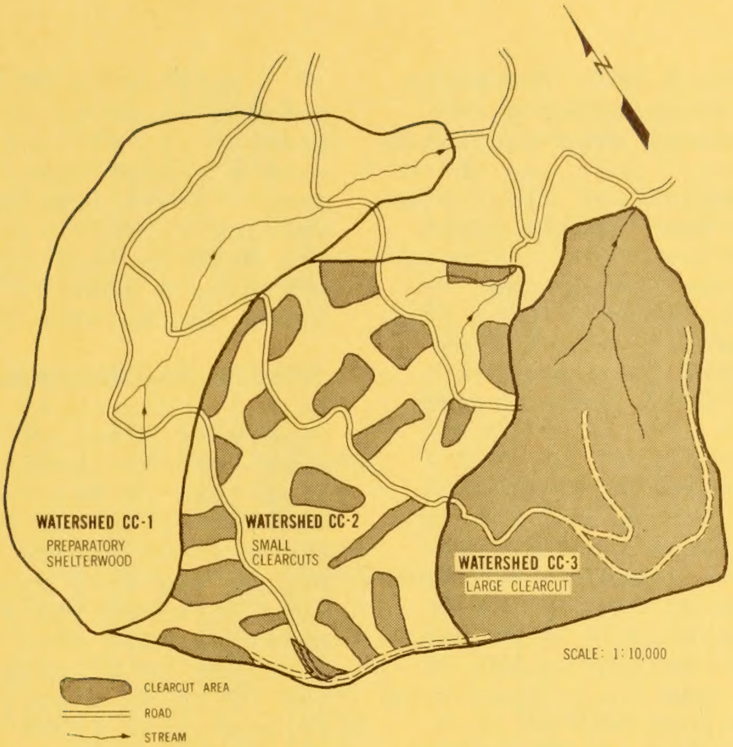

Figure 1.--Map of the three study watersheds, showing roads and cutting units.

reddish breccia and agglomerate parent materials throughout most of the area; clay loams and clays of basaltic origin occupy 5 to 10 percent of the watersheds (Richlen 1973).

In 1971, just before the watersheds were logged, 61 environmental classification plots were established at representative locations in the study area (14 plots in CC-1, 29 in CC-2, 18 in CC-3). Slope, aspect, soil depth (shallow or deep), soil texture, and vegetation were recorded at each location. Radiation, moisture, and temperature indices were then determined for each plot, and the plot environment was described according to the procedure outlined by Minore (1972). Future regeneration success after clearcutting was estimated by using the regression equations listed by Carkin and Minore (1974).

Radiation indices (values determined from slope and aspect measurements) measured on the environmental plots reflected the variety of slopes and aspects found within the study area. They ranged from 0.244 (low) to 0.569 (high). Soils sampled on the environmental plots were deep clay loams and silty clay loams for the most part (74 percent of the plots), but some deep loams (14 percent) and shallow, stony soils (12 percent) were also noted.

Plant species on the environmental plots (*Tsuga heterophylla*, *Clintonia uniflora*, *Anemone deltoidea*, and *Smilacina stellata*, for example) indicated moist conditions throughout the three watersheds. Although all three were moist by South Umpqua and southwestern Oregon standards, CC-3 (moisture index 11.5) was more moist than either CC-1 (moisture index 10.3) or CC-2 (moisture index 9.9). The majority of the environmental plot vegetation indices also indicated cool conditions. Only one-third of the area sampled was classified as "warm" or "hot" by the plant species occurring there. Temperature differences among the watersheds were small. CC-3 (temperature index 5.8) was cooler than either CC-1 (temperature index 6.2) or CC-2 (temperature index 6.9).

When measured elevation, radiation, moisture, and temperature indices were used to predict the future stocking of these areas after clearcutting, CC-3 (predicted stocking = 79 percent) appeared to be better suited to regeneration than CC-1 (predicted stocking = 74 percent) or CC-2 (predicted stocking = 65 percent).

SILVICULTURAL METHODS

All three watersheds were harvested during the summer of 1971, but different methods were used on each. A preparatory cut for creating a shelterwood stand was applied in one watershed (CC-1), clearcutting in the other two. Slash treatment varied, but no broadcast burning was done anywhere on the study area.

Cutting in CC-1 left an average residual overstory basal area of 155 ft^2/acre (6.2 m^2/ha) with a canopy density of 74 percent. Scarification by tractor yarding in this watershed removed the duff on half of the area creating a mineral soil seed bed. Slash was machine-piled and burned.

Twenty small units from 1.6 to 3.3 acres (0.65 to 1.34 ha) in size were clearcut on CC-2; 10 were tractor-yarded and 10 were high-lead yarded. Slash was machine-piled and burned on all the tractor-yarded units. Machine piling was also done on one high-lead unit; on the other nine, slash material more than 8 feet long and 8 inches in diameter (2.4 m long and 20 cm in diameter) was piled by high-lead (YUM[1]-yarded). All landings were ripped after logging was completed.

CC-3 was clearcut as one large 123-acre (49.8-ha) unit (fig. 2). Both high-lead and

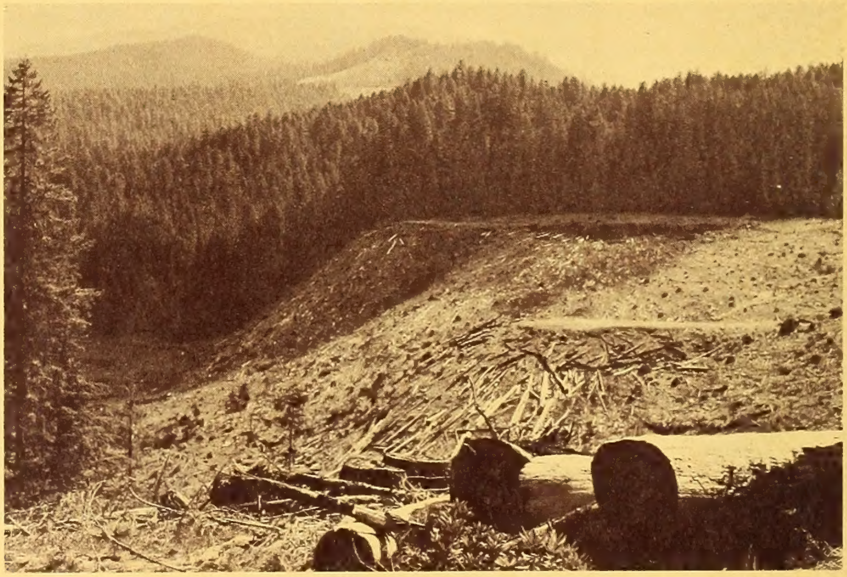

Figure 2.--Lower portion of CC-3 (clearcut in one large unit). May 1976.

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[1] YUM = yarding unmerchantable material.

tractor yarding were used. On portions of the area yarded by high-lead, cull logs were piled on landings. Where tractor yarding was used, slash was machine-piled and burned. The 10 landings used in logging this clearcut were ripped at the end of the operation.

REGENERATION AND SEEDLING GROWTH

Beginning in the spring of 1973, after the first postlogging growing season, regeneration was monitored annually by examining several hundred circular stocking plots. Exact numbers varied each year, but approximately 300 plots were examined in CC-1, 500-600 in CC-2 (25-30 per small clearcut), and 100 in CC-3. The plots were located mechanically in all three watersheds by pacing off uniform distances along evenly spaced compass lines. These compass lines ran across the areas sampled for environmental classification before logging. The same areas were sampled each spring. Remeasurement of identical individual plots was not attempted. Seedlings were counted by species on each 1/250-acre (0.001 6-ha) stocking plot during the first two surveys. After 1974, plot size was reduced to 1/300 acre (0.001 3-ha), and height measurements (the tallest seedlings of each species present) were substituted for seedling counts. A plot was considered scarified if at least half of its area was occupied by mineral soil. Four stocking surveys were completed--one after each growing season. We recorded supplemental measurements of overstory basal area and canopy density in CC-1 in 1976 by using a 10-factor prism and spherical densiometer. Soil bulk density was also measured in all three watersheds during the 1976 survey. Soil macropore space was measured with an air permeameter at several points.

The large clearcut (CC-3) was planted to Douglas-fir before the 1973 growing season. Seven of the small high-lead clearcuts in CC-2 were planted before the 1974 season. Unfortunately, the planting stock used in these areas was in poor condition when planted. Survival of this planted nursery stock was very poor: few planted seedlings were alive after the 1975 growing season. As a result, the stocking percentages measured in the 1973-75 surveys included some planted seedlings, but none are included in the most recent (1976) data.

Because the environmental measurements and stocking predictions indicated favorable conditions for regeneration in all three watersheds, we anticipated successful regeneration. After considering the area in its entirety, we concluded that successful regeneration did occur. There were noteworthy differences in regeneration rate within the study area, however--differences apparently related to harvesting methods (fig. 3). Following a heavy seed crop in 1972, CC-1 and CC-2 promptly regenerated wherever tractor yarding was used--adequate natural regeneration was present in the partially cut stand and in the small tractor-logged clearcut units after the first growing season (table 1.) High-lead units in CC-2 and the large clearcut in CC-3 were slower to regenerate. Scarified areas regenerated sooner than unscarified areas in all three watersheds, regardless of cutting or yarding methods used.

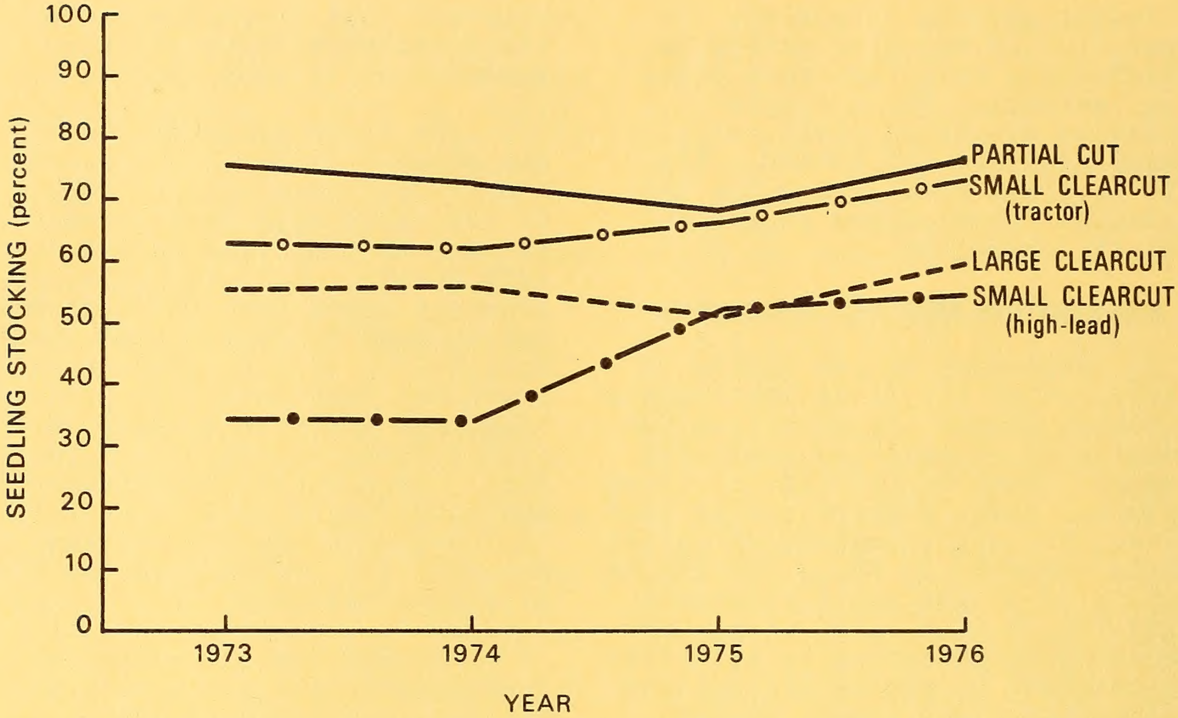


Figure 3.--Stocking of the tree seedlings, by year and harvesting method.

Table 1--*Average number of seedlings per acre*[1] *on three southwestern Oregon watersheds, by species, year, and seed bed*

Watershed and seed bed	Douglas-fir[2]		Incense-cedar		Grand fir		Sugar pine		Ponderosa pine		Western hemlock		All species	
	1973	1974	1973	1974	1973	1974	1973	1974	1973	1974	1973	1974	1973	1974
CC-1 (partial cut):														
Scarified	5,940	14,683	181	1,422	77	1,388	133	608	4	242	0	30	6,335	18,373
Unscarified	1,107	1,857	46	218	149	134	90	107	6	6	6	3	1,403	2,325
Burned	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All seed beds	2,659	5,545	89	564	126	495	104	251	5	74	4	11	2,987	6,940
CC-2 (small clearcuts):														
Scarified	2,486	2,713	403	515	8	138	33	31	0	46	0	13	2,929	3,458
Unscarified	464	716	60	126	13	27	24	37	0	6	0	1	561	913
Burned	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All seed beds	1,372	1,713	214	320	11	83	28	34	0	26	0	7	1,626	2,183
CC-3 (large clearcuts):														
Scarified	365	895	94	169	0	29	302	23	0	221	0	0	760	1,337
Unscarified	243	191	67	22	45	22	41	7	0	22	11	0	407	265
Burned	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All seed beds	275	536	74	95	33	24	110	15	0	122	8	0	500	792
All watersheds combined:														
Scarified	2,936	4,449	345	625	19	328	68	123	1	96	0	14	3,369	5,635
Unscarified	593	1,054	57	149	50	62	42	58	1	7	3	1	748	1,331
Burned	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All seed beds	1,538	2,565	173	361	38	180	53	87	1	47	2	7	1,804	3,247

[1] For number of seedlings per hectare, multiply by 0.405.

[2] The present USDA Forest Service (Region 6) standard for 100-percent stocking in Douglas-fir is 450 well-established seedlings per acre.

Table 2--*Average regeneration stocking on three southwestern Oregon watersheds, by species and seed bed, May 1976*

Watershed and seed bed	Douglas-fir	Incense-cedar	Grand fir	Sugar pine	Ponderosa pine	Western hemlock	All species
				Percent			
CC-1 (partial cut):							
Scarified	65.4	4.8	3.7	9.6	4.8	1.1	89.4
Unscarified	41.3	5.4	10.9	7.6	0.5	0.5	66.2
Burned	0	0	0	0	0	0	0
All seed beds	53.1	5.1	7.2	8.5	2.7	.7	77.3
CC-2 (small clearcuts):							
Scarified	51.4	8.6	4.3	2.2	9.8	0	76.3
Unscarified	29.6	4.3	7.2	5.0	3.6	1.4	51.1
Burned	5.6	0	0	0	0	0	5.6
All seed beds	42.0	6.8	4.8	2.8	7.4	.4	64.2
CC-3 (large clearcuts):							
Scarified	38.8	2.0	0	0	28.6	0	69.4
Unscarified	34.9	2.3	9.3	2.3	7.0	0	55.8
Burned	25.0	0	0	0	0	0	25.0
All seed beds	36.5	2.1	4.2	1.0	17.7	0	61.5
All watersheds combined:							
Scarified	55.0	6.8	3.7	4.4	9.8	.4	80.1
Unscarified	36.1	4.6	9.3	6.0	2.5	.8	59.3
Burned	7.0	0	0	0	0	0	7.0
All seed beds	45.7	5.7	5.7	4.8	6.6	.5	69.0

Postharvest regeneration in the partial cut, CC-1, was more abundant than in either clearcut watershed in 1976 (table 2). Surprisingly, regeneration stocking in the large, 123-acre (49.8-ha) clearcut, CC-3, was only slightly poorer than the average stocking on the 20 small clearcut units in CC-2. Scarified areas had more abundant regeneration than unscarified areas in CC-1 and CC-2, but burned spots had less. Regeneration was abundant on the ripped landings in clearcut areas (fig. 4).

Scarification also benefited the seedling height growth of Douglas-fir in the clearcut areas (table 3). Stocking percent and seedling height growth did not vary consistently with variations in overstory basal area or canopy

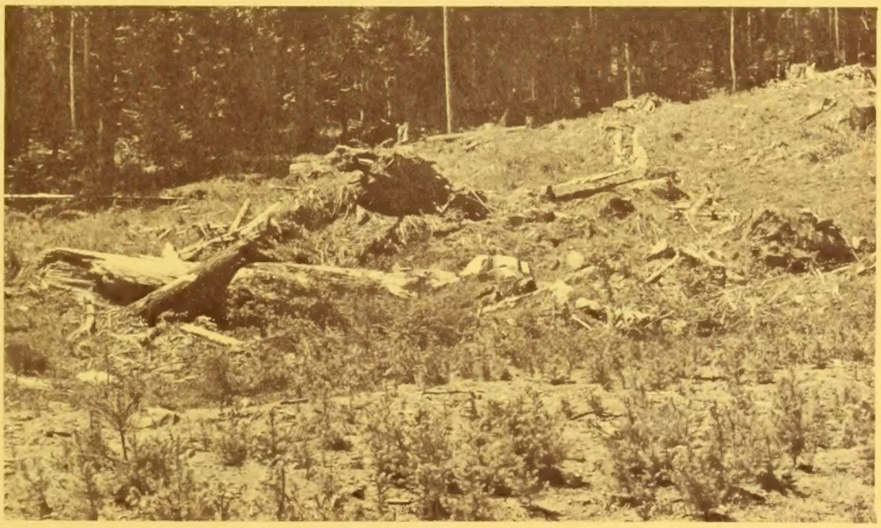


Figure 4.--Abundant natural regeneration present on ripped landing in clearcut area. May 1976.

Table 3--*Average tallest seedling heights on three southwestern Oregon watersheds, by species and seed bed, May 1976*

Watershed and seed bed[1]	Douglas-fir	Incense-cedar	Grand fir	Sugar pine	Ponderosa pine	Western hemlock	All species
	Centimeters						
CC-1 (partial cut):							
Scarified	27.4	19.9	23.2	20.1	28.0	24.5	24.4
Unscarified	21.6	22.8	20.0	18.6	20.0	35.0	21.0
All seed beds	25.8	20.4	22.2	19.8	27.6	29.8	23.6
CC-2 (small clearcuts):							
Scarified	33.1	29.0	28.0	25.7	36.3	21.0	31.5
Unscarified	31.9	31.5	29.3	38.9	42.5	13.0	33.0
All seed beds	32.9	29.3	28.2	30.8	36.8	19.4	31.8
CC-3 (large clearcuts):							
Scarified	39.0	32.6	26.0	29.7	47.8	--	40.6
Unscarified	44.5	--	42.7	14.0	50.0	--	42.5
All seed beds	40.3	32.6	36.0	25.8	48.2	--	41.2
All watersheds combined:							
Scarified	31.4	26.2	26.5	21.7	37.3	22.2	29.6
Unscarified	28.6	28.1	23.3	28.2	43.3	27.7	28.8
All seed beds	30.8	26.5	26.4	23.2	37.7	24.0	29.4
Number of seedlings	543	174	117	107	97	9	1,047

[1] Burned seed beds have been omitted since only 3 seedlings occurred.

density in CC-1. However, seedlings of all species were shorter under the overstory canopy of CC-1 than they were in the clearcuts of CC-2 and CC-3. When all seed beds and all watersheds were considered, we found that ponderosa pine and Douglas-fir were taller than incense-cedar, grand fir, sugar pine, and western hemlock. Douglas-fir accounted for most of the stocking.

Tractor and high-lead yarding effects in the small clearcuts of CC-2 are compared in the following tabulation:

Effect	Tractor units	High-lead units
Average area scarified (percent)	90.4	39.6
Average stocking (percent)	73.6	54.8
Average seedling height (centimeters):		
Douglas-fir	34.0	31.2
Incense-cedar	30.3	26.0
Grand fir	28.1	28.4
Sugar pine	25.5	34.7
Ponderosa pine	35.8	38.8
All species	32.1	31.2

More than twice as much area was scarified by tractor yarding, and natural regeneration was better on the tractor units than it was on high-lead units (figs. 5 and 6). Although the regeneration data were not tallied by yarding method on CC-3, stocking differences between areas where tractor and high-lead yarding occurred were very evident (figs. 7 and 8). Five years after clearcutting, regeneration was most abundant on tractor-yarded areas. Yarding method had little effect on seedling height growth (see tabulation).

Tractor yarding usually results in soil compaction, a condition which often reduces the growth of trees. To assess the influence of tractor yarding on soil compaction and seedling growth, we measured bulk density of the top 4 inches (10 cm) of soil, plus both total height and 1975 growth of an adjacent Douglas-fir seedling at each of 26 points. The points were located on a variety of sites in all three watersheds, from undisturbed forest floor to heavily used skid trails and ripped landings. Bulk densities

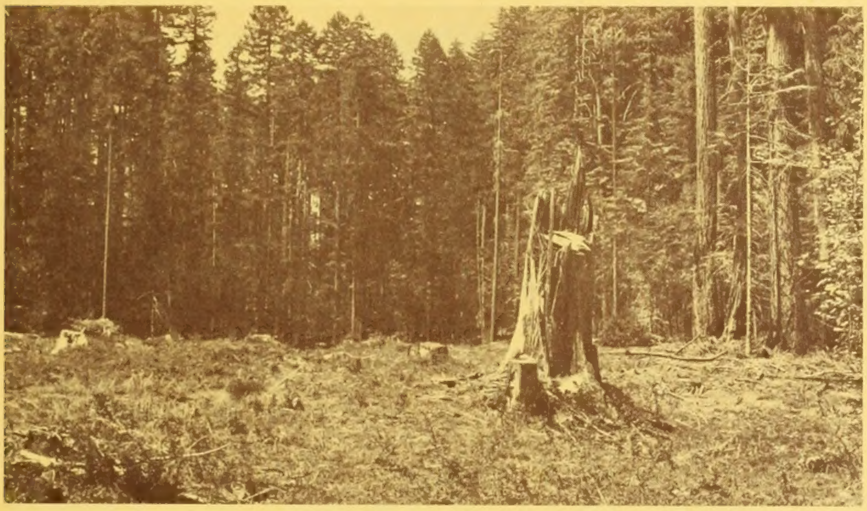


Figure 5.--Portion of a small tractor unit in CC-2. Much of the area was scarified; stocking is excellent. May 1976.

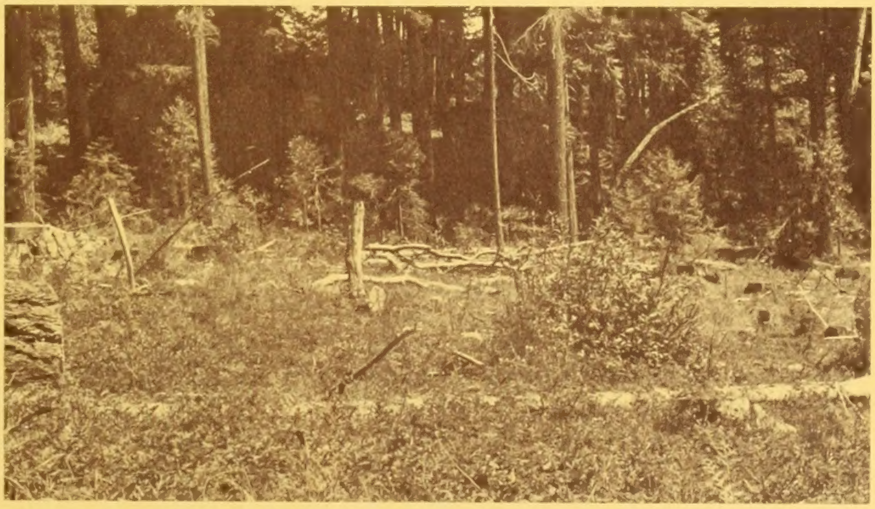


Figure 6.--Portion of a small high-lead unit in CC-2. Much of the area was not scarified; stocking is poor. May 1976.

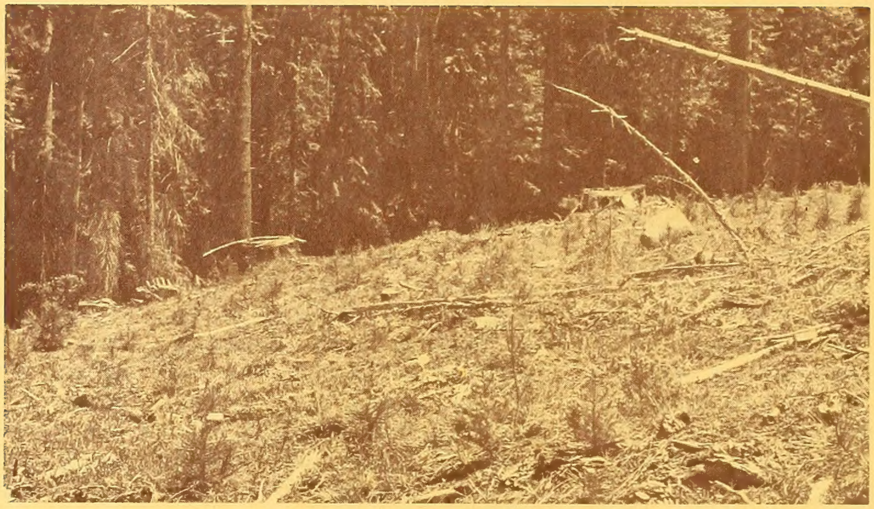
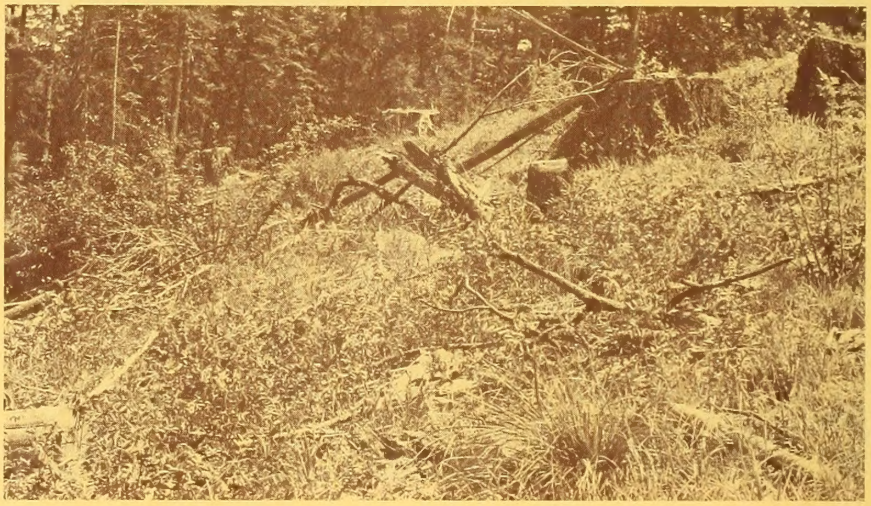


Figure 7.--Tractor-yarded portion of large clearcut in CC-3. Note sparse competing vegetation, absence of debris, and abundant natural vegetation. May 1976.

Figure 8.--High-lead yarded portion of large clearcut in CC-3, approximately 150 feet (50 m) from area shown in figure 6. Note undisturbed vegetation, debris, and lack of regeneration. May 1976.



were low in all measurements--from 0.64 on one undisturbed area to 1.21 on a skid road (table 4).

Tractor yarding increased surface-soil bulk density somewhat in the study watersheds, but this increased density scarcely affected seedling growth during the first four growing seasons after logging. This lack of effect on growth may be misleading. Surface soils are readily loosened by frost heaving and biological activity, but materials deeper than 4 inches (10 cm) remain compacted for many years. Seedlings that grow well in the loosened surface soil may lack rooting space when they become saplings or poles. This compacted soil condition, observed to persist as long as 55 years (Power 1974), is indicated by the bulk density and air permeability measurements taken on tractor logged areas within the watersheds.

Table 4--*Average soil compaction and seedling height growth on three southwestern Oregon watersheds*

Area	Bulk density[2]	Macropore space			Seedling height growth[3]
		Soil depth, 2.5 cm	Soil depth, 15 cm	Soil depth, 30.0 cm	
	Grams/cubic centimeter	- - - - - - -	Percent	- - - - - -	Centimeters
Tractor logged[1]	0.99	21	10	10	7.8
Undisturbed	0.88	34	31	25	10.4

[1] Includes tractor roads and tractor-piled areas.

[2] Measured from the top 4 inches (10 cm) of soil.

[3] Douglas-fir seedling height growth in 1975.

CONCLUSIONS

The three watersheds studied constitute moist, cool environments favorable for regeneration--regardless of the harvesting methods used in removing the old-growth stand. Data and conclusions derived from these watersheds, though not appliable in the warm, dry conditions found in much of the South Umpqua River basin, have important implications for the future management of similar environments. The increased stocking obtained after the preparatory shelterwood cut does not seem to be worth the increased logging effort and decreased seedling growth rates involved. If shelterwood cutting is applied in similar environments, soil scarification should increase both regeneration stocking and subsequent early seedling growth.

Clearcutting is probably the best harvesting method for moist, cool environments similar to those of the study watersheds. Large clearcut units like the one occupying CC-3, however, are less desirable than smaller units like those in CC-2. Environmental conditions on CC-3 were more favorable before harvesting than those on CC-2, yet regeneration was poorer. This may be attributed to the postharvest environmental differences associated with differing clearcut sizes on CC-2 and CC-3. Individual species stocking also varied with clearcut size (table 2). Ponderosa pine regenerated best in the large clearcut. Douglas-fir, incense-cedar, grand fir, and sugar pine were more successful in the small clearcuts.

In terms of initial regeneration success, tractor yarding was superior to high-lead yarding; however, the relatively small increases in surface soil bulk density and relatively large decreases in subsoil macropore space associated with tractor yarding may impede future seedling growth.

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